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CONTENTS

Soilless culture of seedless greenhouse cucumbers and sequence cropping

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Preface

Interest in soilless culture of horticultural crops has become worldwide in recent years. It can become a fascinating hobby, particularly in locations where conventional cultural methods are impractical. In too many instances, however, this interest has led to an enthusiasm for its use as a practical means of crop production, which is not always the best method for the particular circumstances.

A method of producing greenhouse tomatoes with sawdust as the growth medium instead of soil was developed at the Saanichton Research and Plant Quarantine Station as a way of overcoming the problem of declining yields of tomatoes in commercial greenhouses on Vancouver Island (Adamson and Maas 1971, 1976; Maas and Adamson 1980). The method has been widely adopted in British Columbia. Although fewer problems have been encountered by growers of greenhouse cucumbers, the second most important greenhouse vegetable crop, the incidence of soil-borne diseases in this crop has increased in recent years. This increase, together with the success of the soilless method for tomatoes, led to research into the feasibility of soilless production for greenhouse cucumbers and to the development of the sequence cropping system described in this publication.

The authors acknowledge the technical assistance of the late D. R. Cook and of E. C. Lovejoy and W. T. Murdoch, Saanichton Research and Plant Quarantine Station, Sidney, B.C.

*Retired 1977.

Introduction

The seedless, long English, or European cucumber, as it is variously called, has surpassed the seeded type in importance for greenhouse production in British Columbia and was therefore selected for the experiments. It is increasingly popular, mainly because of its fine texture and tender skin and flesh, and because many people find it easier to digest than the seeded cucumber.

Although by standard growing practices it is more exacting in its cultural requirements, and its fruits have a shorter shelf life, the seedless cucumber has a big advantage over the seeded type because the fruit develops without fertilization. Bees, therefore, are not needed in the greenhouse to pollinate the flowers.

In these experiments it was determined that with some modifications in nutrient formulations and production methods, cucumbers, like tomatoes, can be grown readily in a sawdust growth medium. To reduce the problems usually experienced in keeping seedless cucumbers bearing well throughout a season, which may extend from March until October, the technique of sequence cropping was developed. In sequence cropping, a number of short-term crops are grown in the same greenhouse. Because the fruit is produced on young vigorous plants, production tends to be sustained evenly throughout the season. Pruning and training are simple and straightforward, and each crop is handled in a similar manner, allowing the use of inexperienced labor. Although sequence cropping has worked well at the Saanichton Research and Plant Quarantine Station, modification of the procedures may be needed in other circumstances.

Standard soil-growing procedures are not described in this publication, but they can be found in the References (British Columbia Ministry of Agriculture and Food 1980; Great Britain Ministry of Agriculture, Fisheries and Food 1977; Loughton 1972; Ontario Ministry of Agriculture and Food 1980). The growing of cucumbers on straw bales (Great Britain Ministry of Agriculture, Fisheries and Food 1977; Loughton 1975) is a fairly recent innovation and a step toward soilless culture.

The growth medium

Sawdust, sand, and mixtures of the two have been used successfully for cucumber production. A mixture containing 25% or more sand has the advantage of permitting a more uniform distribution of moisture than sawdust alone. This advantage, however, must be balanced against the extra cost of supplying and mixing the two ingredients. In coastal British Columbia, sawdust from Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) or western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) is the most readily available. Other kinds have also proved suitable, but sawdust from western red cedar (*Thuja plicata* J. Donn ex D. Don) is toxic to cucumber plants, particularly when the sawdust is fresh, and should not be used.

Containers

Although cucumbers can be grown satisfactorily in single rows in wooden-sided beds (about 25 cm wide and 15 cm deep), the use of a plastic bag for each plant allows greater flexibility in sequence cropping. When cucumbers are grown in bags, the 10 L of sawdust usually provided for each tomato plant is insufficient. Bags that contain about 30 L are more satisfactory because there is less fluctuation in the moisture content of the growth medium. The method of using one plant per bag reduces the danger of spreading disease if there is an incidence of root-disease infection.

Cultivars

A great many improved cultivars of seedless greenhouse cucumbers have been developed in recent years, mostly F_1 hybrids. Some are all-female with fruit-bearing flowers at each leaf axil along the main stem, rather than on lateral stems only. These all-female cultivars have proved to be well adapted to sequence cropping and permit quick pruning. Cultivars that have been tested and have proved to be suitable for sequence cropping include Pepinex, Farbio, Uniflora C, Uniflora D, Simex, Virgo A, and Pandex. Many of the new cultivars that appear each year would probably be equally satisfactory. There may also be differences among cultivars in their seasonal adaptation, and so the possibility of changing the cultivar during the season should be considered.

Nutrition

The nutrient formulas (Formulas A–D) for tomatoes and cucumbers are similar, the required phosphorus (84 ppm P_2O_5) and potassium (252 ppm K_2O) levels being the same for both crops at all stages of growth. Before the seedlings are transplanted, the required nitrogen level for both crops is 126 ppm. After the cucumbers have been transplanted, however, the nitrogen level must be maintained at 168 ppm and the calcium level increased by 28% (Formulas C and D).

Either Formula A or Formula B may be used for feeding seedlings before they are transplanted. Of these the premix formula, in which dry fertilizer ingredients are mixed with the 2:1 peat–vermiculite propagating medium, has the advantage of not requiring further additions of fertilizer.

Table 1

Minor element stock solution

	Iron chelate mix g	Iron citrate mix g	Amounts in final nutrient solution
Iron	76.0	45.0	1.65 ppm Fe
Manganese sulfate*	8.0	8.0	0.54 ppm Mn
Boric acid*	13.0	13.0	0.46 ppm B
Zinc sulfate	2.2	2.2	0.11 ppm Zn
Copper sulfate	0.6	0.6	0.034 ppm Cu
Molybdic acid	0.2	0.2	0.023 ppm Mo
	100.0	69.0	

Note: The minor element mixes used at the Saanichton Research and Plant Quarantine Station are available commercially, with iron in either chelate (10% iron) or citrate (16.7% iron) form, and contain the ingredients listed above. To prepare the solution, dissolve 100 g of dry iron chelate mix in 1 L of warm water and store it in a dark bottle. For the iron citrate mix, which is preferred for the premix method (Formula B), dissolve 69 g of iron citrate mix in 1 L boiling water and store it in a dark bottle.

*In some cases the levels of manganese sulfate and boric acid may require adjusting, based upon the results of leaf analysis and the advice of your district horticulturist.

Formula A

This formula is for feeding seedlings that will be transplanted; it contains 126 ppm N, 84 ppm P_2O_5, and 252 ppm K_2O.

	per 1000 L of dilute solution
Potassium sulfate (0-0-50)	500 g
or	
Potassium chloride (0-0-60)	420 g
Magnesium sulfate (Epsom salts)	500 g
Diammonium phosphate (21-53-0)	160 g
Calcium nitrate (15.5-0-0)	600 g
Minor element stock solution (see Table 1)	200 mL

Formula B

This formula is a premix for feeding seedlings that will be transplanted.

	per 100 L of growth medium
Mag Amp (7-40-6)	600 g
Osmocote (18-6-12)	300 g
Osmocote (14-14-14)	150 g
Minor element stock solution (see Table 1)	50 mL

Formula C

This formula is to be used after transplanting and contains 168 ppm N, 84 ppm P_2O_5, and 252 ppm K_2O.

	per 1000 L of dilute solution
Potassium sulfate (0-0-50)	270 g
or	
Potassium chloride (0-0-60)	225 g
Phosphoric acid (75%)	100 mL
Potassium nitrate (13-0-46)	250 g
Calcium nitrate (15.5-0-0)	870 g
Magnesium sulfate (Epsom salts)	500 g
Minor element stock solution (see Table 1)	200 mL

Formula D

This formula is to be used after transplanting and contains 168 ppm N, 84 ppm P_2O_5, and 252 ppm K_2O.

	per 1000 L of dilute solution
Potassium sulfate (0-0-50)	500 g
or	
Potassium chloride (0-0-60)	420 g
Diammonium phosphate (21-53-0)	160 g
Calcium nitrate (15.5-0-0)	870 g
Magnesium sulfate (Epsom salts)	500 g
Minor element stock solution (see Table 1)	200 mL

Formula preparation

For Formulas A, C, and D, dissolve each fertilizer separately in hot water and add it in turn to the required amount of water, stirring vigorously. It is usually best to add calcium nitrate last. For Formula C, add phosphoric acid first to prevent clouding by the other ingredients.

If the pH is below 6.0, bring it into the desired 6.0–6.5 range by adding pelleted potassium hydroxide. For Formulas A and D, if the final solution has a pH above 6.5, it may appear milky but can be cleared by adding 50–100 mL of sulfuric acid (specific gravity 1.265) per 1000 L of nutrient solution to bring it into the pH 6.0–6.5 range. It is best to add the acid first, as in Formula C.

Raising plants for transplanting

The seed of all-female cucumber cultivars is expensive, and it is therefore imperative to obtain a high percentage of good-quality transplants, particularly in sequence cropping, which requires several sowings. The following method, which can be modified to suit individual requirements, has been consistently successful.

Treat the seed with a protectant to safeguard the seedlings from damping-off disease and sow the seed on blotters wrapped in toweling or use other means to keep the seed moist at a temperature of 25°C. In about 24 hours the primary roots begin to emerge. After 40 hours, when the seedlings are about 20 mm long, remove them and prick them out individually into the prepared containers.

Plastic pots 10 cm in diameter make suitable containers. Fill them loosely with a 2:1 peat–vermiculite mixture and add hydrated lime at 200 g/100 L water to adjust the pH. To promote quick rooting, firm the medium with a wooden tamper, to which a No. 10 rubber stopper has been centrally fastened. Fill the resulting depression with a 1:1:1 mixture, by volume, of fine peat, perlite, and medium-coarse sand (Fig. 1); firm the mixture and prick out the germinating cucumber seed into the individual pots (Fig. 2).

Two alternative methods for supplying nutrients may be followed: the first requires a daily application of a complete, dilute nutrient solution (Formula A) whenever moisture is needed and the second calls for all fertilizer ingredients to be premixed into the growth medium, with the minor elements supplied in solution during the initial moistening (Formula B). With the latter method, water the young plants only whenever moisture is required between the time of pricking out and transplanting. Both methods have given equally good results. Until the seedlings are well emerged, keep the surface moist with water from a fog nozzle. After the seedlings have emerged, provide moisture with a nutrient solution or with water, as appropriate, in amounts necessary for their development. To prevent bending the stems, pour the liquid around the edges of the pot instead of overhead sprinkling.

Early in the season, when light intensity is low, provide additional light for 12 hours a day with cool white fluorescent lights to help keep the plants stocky. The temperature should be held at about 20°C. After 10 days to 2 weeks, space out the pots to avoid crowding. About 3 weeks after sowing, the cucumber plants develop their fourth true leaf and can be removed from the pots for transplanting, with their root ball intact.

FIG. 1 Preparing the propagating pots for cucumber transplants: a tamper with a rubber stopper used for firming the peat–vermiculite growth medium (*left*); a depression ready to be filled (*center*); filling the depression with peat, perlite, and sand (*right*).

FIG. 2 Transplanting the germinating cucumber seed into the propagating mixture.

Spacing and transplanting

In sequence cropping of cucumbers that are grown in bags of sawdust, fill all bags at the beginning of the season and place them in tightly packed rows with 30 cm between the centers of adjacent bags (Fig. 3). Plants of the same planting occupy alternate bags, so that there are 60 cm between them. Plants of the succeeding planting occupy the vacant bags (Fig. 4). No further attention to the placing of bags is required, and three crops are produced in each bag during the season. When plants are grown in wooden-sided beds filled with sawdust, the plants should be spaced 60 cm apart, and thus subsequent plantings started between the original plantings will also have 60 cm of space between them.

Plantings at the Saanichton Research and Plant Quarantine Station are usually trained to grow in an inverted V configuration to conform to available space. This has worked well, but other arrangements would also be suitable. The space between the wide rows of plants is 2.3 m and between the alternate rows, 0.6 m. The area provided for each plant is therefore 0.9 m^2, not counting the space required for end pathways. Because two plantings of different ages are in the greenhouse for part of the time, each plant during this period occupies 0.45 m^2 of space.

To ensure ready establishment, moisten the sawdust with nutrient solution just before transplanting. Alternatively, position the pots in the bags or beds a day or two before transplanting them and place a feeder tube into the pot, so that the plants are kept moist and any excess solution drains into the sawdust beneath. For the second and subsequent

FIG. 3 Transplanting the cucumber plants into bags of sawdust, about 25 days after starting the seed.

FIG. 4 After the cucumbers have been transplanted, sand is spread over the surface of the sawdust to improve moisture distribution. The second planting of the season will occupy the vacant bags.

plantings, position transplants toward the outer edge of the bag or bed, away from the foliage of the previous planting. This way, the young plants have better access to light and develop more compact growth.

Place a layer of sand 1.25–1.5 cm deep on the surface of the sawdust immediately after transplanting. This ensures a better distribution of moisture in the sawdust medium and is especially important when plants are grown in bags, because the growth medium for each plant has no contact with the medium of the bag adjacent and the risk of drying out is greater.

For the second and subsequent plantings it is helpful to train the plants to grow up 1-m canes that are inserted vertically into the medium in rows, fastening them to the canes with tape or twist ties. This procedure keeps the plants more fully exposed to sunlight, and they remain more compact. By the time the plants reach the top of the canes and are ready to be fastened to the upright strings, the basal leaves of the previous planting should already be removed. These precautions are designed to permit the maximum amount of light to reach the new plant, and if you fail to observe them, the vines become too leggy and the crop is reduced.

Applying the solution

The trickle tube method (Mason and Adamson 1973) of applying nutrient solution to each plant has proved successful. For sequence cropping of seedless cucumbers in soilless media, however, provide two tubes for every plant in the greenhouse so that one, two, three, or four tubes, as required, can direct some solution to each plant of any one planting. By the use of a timer to start and stop the pump at preset times, the amount of nutrient solution can be adjusted to meet the requirements of two different plantings.

Cucumbers need more moisture as the plants develop, and as much as 4.5 L or more per plant per day are needed when the plants are producing fruit. Preset applications of nutrient solution during the day will help to adjust the supply to plant demand. This, along with the appropriate pruning procedures to avoid aborting of fruit, will help to produce good yields.

Temperature and humidity

Temperature and humidity requirements for crops grown in a soilless medium are similar to those for crops grown in soil. This also applies to tomatoes, although somewhat higher tempertatures are needed for best development of cucumbers. Daytime temperatures should be about 26–30°C, and nighttime temperatures about 18–20°; use slightly lower settings during dull weather. Mist the foliage and pathways, thus keeping the relative humidity high enough to prevent the leaves from drying out and wilting. Provide enough air circulation to minimize the incidence of foliage diseases.

Schedules for sequence cropping

The objective of sequence cropping is to produce a steady supply of high-quality fruit. It is therefore essential to adopt a suitable schedule and adhere to it closely. The following full-season schedule is based on actual experience at the Saanichton Research and Plant Quarantine Station. It should be regarded as an example only and can be modified to suit individual circumstances.

Planting	Sow	Transplant	First Pick	Last pick
1	January 5	January 31	March 9	April 10
2	February 16	March 13	April 14	May 14
3	March 30	April 23	May 19	June 18
4	May 5	May 27	June 23	July 23
5	June 10	July 2	July 29	August 28
6	July 14	August 6	September 4	October *

*The sixth planting can be trained to produce fruit for an extended period, depending on crop conditions and economic factors.

Pruning and training in sequence cropping

A successful greenhouse cucumber crop depends on the ability of the grower to achieve a high level of production and quality throughout the year. The growing area that can be devoted to the crop is limited by the experienced labor available. Because pruning and training the plants are critical operations in the successful management of the crop, a system such as sequence cropping, which uses procedures that can be followed by inexperienced labor, has obvious advantages. The pruning and training method described has been developed to permit harvesting at least 12 marketable fruits per plant for each of 6 successive plantings, for a total of 72 fruits per plant space during the season. With this method, the picking season of each planting is about a month long, so that when the first sowing is in early January, fruit can be picked from mid-March to mid-October. This allows for an interval of a few days between the time that the harvesting of one planting is completed and that of the next one is begun.

Typical training systems for seedless cucumbers are *arch* or *cordon* (British Columbia Ministry of Agriculture and Food 1980; Loughton 1975). These systems and modifications of them are labor intensive, and require close attention to detail and considerable experience. Although sequence cropping requires extra seed and the growing of transplants for the additional plantings, the pruning and training procedures are relatively simple and straightforward. The growing period for each crop is of a much shorter duration, and procedures are simply repeated for each planting.

In sequence cropping the plants are trained to grow up twine that is supported by horizontal wires. Because all lateral shoots are removed and only a single fruit is permitted to develop at each main stem node (Fig. 5), pruning is a simple, quick procedure and can be accomplished in about 30% less time compared with the usual method of producing fruits on lateral stems. Because all cucumbers are produced on young vigorous plants, they mature quickly with good quality (Fig. 6).

Pruning studies show the importance of removing all shoots and flower buds from the axils of at least the first seven leaves (Fig. 7). This delays fruit formation but permits the development of leaves and a root system to support fruit development, with a minimum of aborting. Because the first fruits may develop higher up on the plant than desirable, thus tending to reduce crop potential, the vine should be allowed to sag near the base so that the first fruit is picked from a lower position on the branch than would otherwise be the case. Subsequent thinning, such as removing all growth at the appropriate node (Fig. 7*a*, nodes 11, 14, and 17) helps to reduce stress during the early part of the picking season and encourages later fruit production.

Another alternative is to remove the stem fruits at nodes 11, 14, and 17, thereby permitting a single lateral shoot to develop at each of these three nodes or at other selected positions. A single fruit is harvested at the first node on these lateral branches, and further growth is prevented (Fig.

FIG. 5 The first crop of the season starts to produce flowers about 25 days after transplanting. Note that the flowers are produced on the main stem.

FIG. 6 Fruit of two suitable cultivars produced by the sequence cropping method.

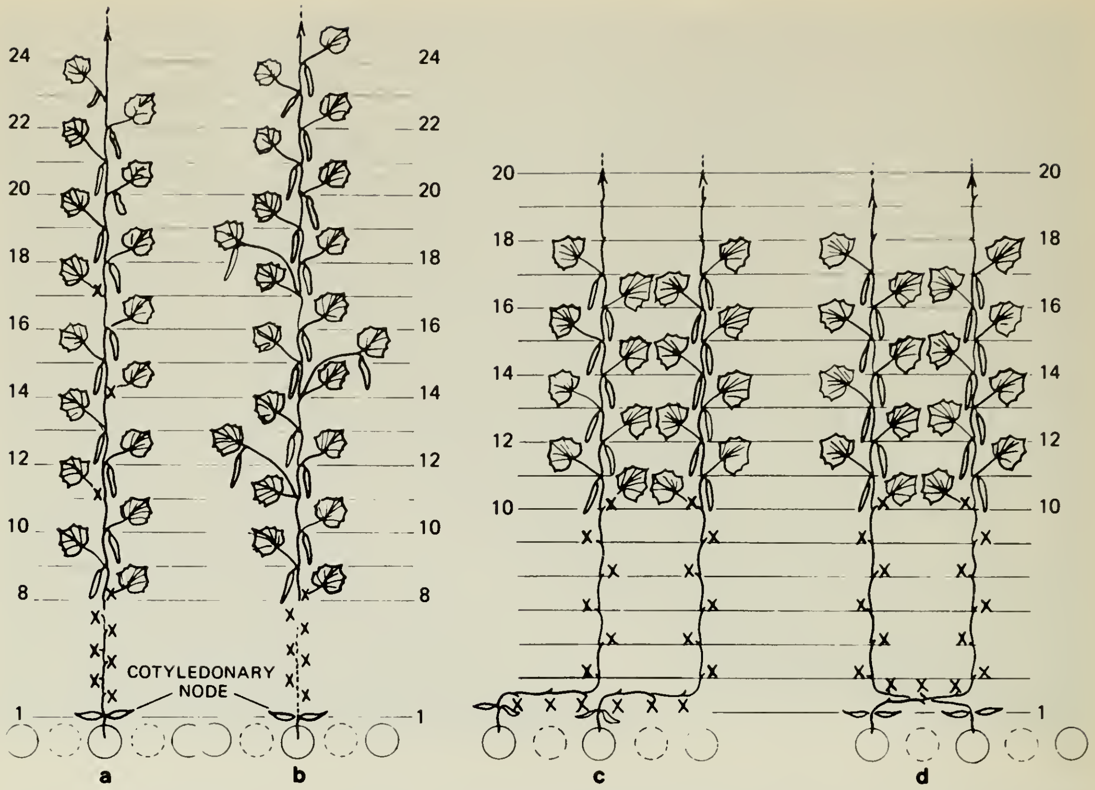

FIG. 7 Pruning and training in the sequence cropping of cucumbers. X shows where the leaves have been removed.

7b). The extra leaf and the resulting delay in producing the lateral fruit help to avoid stress. Another option is to train each plant to grow laterally along the surface of the medium to the next plant of the same planting and then to grow up the twine of that plant. All the plants can be trained to grow in one direction (Fig. 7*c*) or they can be trained in pairs, one of each pair being made to grow across and up the twine above the other's position (Fig. 7*d*). Although production is further delayed by the removal of all shoot growth until node 11 from plants so trained, the yield potential is maintained because early leaf and root development is encouraged, and the possible consequence of fruit aborting thereby reduced. With this method there is either no subsequent pruning, thus simplifying the work, or additional pruning is done to produce lateral fruits as described.

It is a good practice to leave two buds (each a potential fruit) on the main stem when removing lateral shoots and excess flower buds from the axils of the leaves. When the buds have reached the blossom stage, one of them can be removed. This late selection helps to ensure that the flower remaining will produce a marketable fruit, because damage to flower buds, which could cause fruit loss or malformation, is more likely to occur when the buds are small. For the first five plantings, the main stem is simply terminated when it reaches the overhead wires. For the sixth planting, laterals may be permitted to grow down from the upper two nodes for extended cropping, after the main stem is terminated.

Harvesting

Harvesting usually starts 25–35 days after transplanting, the longer period being required in the early part of the season, when light intensity is low and day length shorter than for subsequent plantings. Fruit is usually picked three times a week and is ready for harvesting when it is dark green, is uniform in thickness for its full length, has ceased to lengthen, and has reached marketable diameter (see Fig. 6). Marketability is usually high in sequence cropping, probably because the fruit is harvested from relatively young hybrid plants with vigorous root systems.

Greenhouse sanitation

In sequence cropping for the entire season, the greenhouse is occupied by cucumber plants from late January until October, and therefore sanitary practices can be carried out only during the late fall or early winter. As soon as possible after cropping, remove old vines, twine, and bags of used sawdust. Wash ceilings, walls, trusses, and gutters. Also wash heating pipes, purlins, support wires, and floors with a 1:9 household bleach–water solution or a 1:25 Formalin–water solution. Also, if wooden beds are to be used, wash any parts that do not come in contact with steam. If you apply Formalin, use an approved respirator, isolate any growing plants from the fumes, and ventilate the greenhouse thoroughly. Make sure that the atmosphere is safe by putting a few plants into the greenhouse and, after 24 hours, checking to see if they are damaged.

If a growth medium is to be used a second season, it should be steam sterilized for at least 30 min at 80°C. New media do not require sterilization before use. Soilless media can be used for several years, if they remain porous. Surface steaming is effective in sawdust beds to the full depth of the sawdust but only to 10 cm for a 3:1 sand–sawdust mixture. To surface steam sawdust beds, dig in a row of agricultural tile and introduce steam into it. Immediately after steaming and before planting, leach the beds with water, if necessary, to reduce the conductivity to 2 mS/cm and the nitrate nitrogen to below 100 ppm (see "High salt concentration").

Diseases and insects

One of the major benefits of growing cucumbers in a soilless culture is the freedom from soil-borne plant diseases and nematodes. For best results, follow closely the steps outlined in "Greenhouse sanitation". Also, make sure that the media, containers, and other tools and utensils do not become contaminated. Insects, particularly the greenhouse whitefly, twospotted spider mite, and thrips can be troublesome. Biological control of the greenhouse whitefly (McClanahan 1972) and the twospotted mite (Tonks and Everson 1977) has been investigated in Canada and shows

promise for practical control of these pests. Whitefly parasites (*Encarsia formosa* Gahan) and predators of the twospotted spider mite (*Phytoseiulus persimilis* Athias-Henriot) are now available to commercial growers from the Saanichton Research and Plant Quarantine Station. Recommendations for disease and pest control are available from the British Columbia Ministry of Agriculture and Food and the Ontario Ministry of Agriculture and Food.

Fruit disorders

Aborting

Immature fruits can turn yellow and then become brown when they are about 2.5–5 cm long, although they sometimes develop to a later stage before they are affected. This condition is termed "aborting." It appears to result from stress caused by a heavy load of fruit before the plant has developed an adequate root system or leaf surface. It is also influenced by insufficient moisture and nutrients, and by extreme temperatures. When the plant's capacity to develop fruit is exceeded, aborting usually occurs at several successive leaf axils before normal fruit development resumes. In a sequence-cropping program this obviously causes a serious disruption of orderly harvesting and marketing, because successful cropping depends entirely upon the harvesting of fruits at each leaf axil on the main stem. The methods described in "Pruning and training in sequence cropping" were designed to prevent fruit from aborting. There is a tendency for some of the later fruits in a planting to remain small and become pointed at the blossom end, and this appears to be a condition closely related to aborting.

Crooked and waisted fruits

Bent or crooked fruits often result from inadequate attention during the early stages of their development. Because the sequence cropping system requires strict adherence to a set pruning scheme, the incidence of "crooks" is usually low. Fruit that is allowed to develop and hang free usually grows straight. For this reason, inverted V training produces fewer crooks than vertically trained plants. It is important to ensure that very young fruits develop unencumbered by strings, wires, leaves, or stems, because straightening the fruit at a later stage is usually impractical. Sometimes fruits develop a conspicuous "waist," or constriction, at mid-length. This is more evident in some cultivars than in others and appears to be related to a check in growth.

Management problems

High salt concentration

A rise in the salt concentration of the growth medium is a management problem that can have serious consequences. It may result from a

lack of adequate moisture, extreme greenhouse temperatures, or an error in preparing the nutrient solution. The first symptoms are small brown spots that appear on the upper surface of the lower leaves, which rapidly become larger and which may lead to complete defoliation in the affected area. Depending on the age of the plant (the younger ones are more sensitive), a rise in salt concentration can cause the symptoms to appear. A test can be made with a relatively inexpensive conductivity meter, which is a worthwhile investment for commercial growers. Conductivity is expressed as millisiemens per centimetre (mS/cm), with a desired range of 2.0–2.5, but other scales are also in use. Growers who buy a conductivity meter should check with their local agricultural authority for the correct interpretation. For an approximate check, dissolve 1 g of dry table salt in 1 L of distilled water. It should read about 1.9 mS/cm at room temperature.

Both pH and conductivity of the solution contained in samples of the growth medium taken from the root zone can be determined by squeezing the sample with a mechanical press. Plans for such a press, which can be made at a machine shop, are available from the Saanichton Research and Plant Quarantine Station.

For quick correction of a high salt concentration, leach the medium with up to 5 L of water per plant. The water can be applied through the feeder tubes or by hand. Then resume nutrient feeding. During hot weather this procedure can be repeated once a week, as a safeguard against an undue rise in the salt concentration.

General

Other management problems may result from the absence of a suitable schedule or from neglecting to ensure that the young plants have adequate light. Light is particularly important for new transplants in the early part of the season when days are short and dull, as well as later in the season, whenever the weather is cloudy for more than a day or two. It is therefore advisable to transplant the plants into the outer edges of the bags and to train them to grow up canes, well away from the foliage of the previous planting, so that they get as much direct sunlight as possible during this critical stage. Another precaution is to remove the lower leaves from the older plants so that they do not shade the leaves of the succeeding planting or reduce the amount of reflected light. However, do not remove leaves too soon, and then only three at a time. Failure to observe these precautions induces rapid internode elongation and consequently reduces the total number of fruits that can be harvested.

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CONVERSION FACTORS

Metric units	Approximate conversion factors	Results in:
LINEAR		
millimetre (mm)	x 0.04	inch
centimetre (cm)	x 0.39	inch
metre (m)	x 3.28	feet
kilometre (km)	x 0.62	mile
AREA		
square centimetre (cm^2)	x 0.15	square inch
square metre (m^2)	x 1.2	square yard
square kilometre (km^2)	x 0.39	square mile
hectare (ha)	x 2.5	acres
VOLUME		
cubic centimetre (cm^3)	x 0.06	cubic inch
cubic metre (m^3)	x 35.31	cubic feet
	x 1.31	cubic yard
CAPACITY		
litre (L)	x 0.035	cubic feet
hectolitre (hL)	x 22	gallons
	x 2,5	bushels
WEIGHT		
gram (g)	x 0.04	oz avdp
kilogram (kg)	x 2.2	lb avdp
tonne (t)	x 1.1	short ton
AGRICULTURAL		
litres per hectare (L/ha)	x 0.089	gallons per acre
	x 0.357	quarts per acre
	x 0.71	pints per acre
millilitres per hectare (mL/ha)	x 0.014	fl. oz per acre
tonnes per hectare (t/ha)	x 0.45	tons per acre
kilograms per hectare (kg/ha)	x 0.89	lb per acre
grams per hectare (g/ha)	x 0.014	oz avdp per acre
plants per hectare (plants/ha)	x 0.405	plants per acre

DATE DUE

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